A CONTRIBUTION TO THE LOCALIZATION OF FOCAL LESIONS IN THE PONS OBLONGATA TRANSITION.

By E. C. SPITZKA.

(Continued from p. 205.)

ONE remarkable feature of the diseased area was that the topographical details, such as the natural demarcation lines separating various nerve-strands and ganglia were clearly recognizable. The disease had invaded the nerve nuclei and the sagittal nerve-tracts distinctively; but as those nerve fibres which run in the plane of such sections as are made transversely to the peduncular axis were not destroyed, the intricate fielding of the reticular formation of the raphe and its contiguous fields, as well as the arciform fibres, was not obliterated. On the contrary, it appeared even more distinct than on the healthy side; as it were, every detail being exaggerated.

MICROSCOPIC CHARACTERS.

The characteristic feature of the diseased area is the presence, in enormous numbers and enlarged dimensions, of bodies which in every respect resemble the so-called granular elements of the neuroglia. The greater number of these bodies do not exceed the maximum dimensions of normal neuroglia elements, but some are half as large again, and a few nearly double that size. Together with the stroma, they make up the mass of the new formation. The stroma, in most part, particularly in the region corresponding to the reticular field, resembles the normal neuroglia. If any thing, the molecules appear a little coarser and more glistening. In other regions, particularly where regressive changes appeared to have been in preparation, there is a well-developed supporting frame-work of colorless, transparent substance, resembling the supporting mesh-work of the retina. It cannot be stained, as a whole, by any agent, but in some places it includes faintly-stained, round nuclei in the larger trabecula which make up the mesh-work. The nuclei before referred to could be brushed out of this supporting frame-work, just as the granular and ganglionic elements of the retina may be removed from the enclosing basis-substance by a similar procedure.

The blood-vessels have undergone a considerable hypertrophy, so much so that the contour of the diseased area can be pretty accurately traced by their injection. They are everywhere more numerous than on the healthy side, and contorted, zigzag, or of a corkscrew shape. They also show considerable distension, and this not evenly, but here and there, producing fusiform expansions of the vascular contour. The increased vascularity is particularly marked in those places which are naturally most vascular; thus the lower facial and the motor nuclei of the mixed system are practically converted into a convoluted maze of blood-vessels. As these stain in clearest contrast in fuchsine, sections prepared with the latter agent were used to make the drawings of figures 3 and 4 from.

In several instances a yellowish amorphous substance is found in the subadventitial space of the blood-vessels; and this occurrence is found limited to the diseased area. Otherwise the walls are normal.

The scattered nerve elements found in the mesh-work of the reticular substance and in the upper strata of the trapezium are much larger on the affected side than on the one which in this level is unaffected. I find every transition between the smaller as well as the medium-sized ganglion cells and the characteristic elements of the new formation. Usually the processes are not as distinct as in typical nerve cells, but in a few cases even this requirement of the standard ganglion cell is complied with.

A number of foci are found within the growth which do not stain as the rest does. On examining one of these foci, situated at the border of the subendymal gray substance, midway between the abducens nucleus and the lateral angle of the ventricle, a beautiful transition is observed between free nuclei of the neuroglia and round vesicular bodies scattered through a finely molecular substance surrounding and merging into the pale area. The transition is best expressed as follows:

1. Typical neuroglia nuclei.
2. Ditto, enlarged, pale, and surrounded by a little protoplasm.
3. Ditto, and surrounded by a clear space.
4. Vesicle containing nucleus, surrounded by a little protoplasm.
5. Simple vesicle, without nucleus.

This transition corresponds exactly to that claimed by Hubrich[1] and Forel[2] for certain clear bodies found in the gray substance of lower mammals and in the cortex of paretic dements.

As to another form of body occurring in the affected area, I am unable to offer any explanation. It seems equally to present every transition to the neuroglia nucleus, but is entirely different from the ganglionic as well as the vesicular elements just described. Such elements stain a little more deeply in hæmatoxylin and of a higher shade in carmine than the former; but to fuchsine and other anilines they react in the same manner. The smaller of these bodies contain a distinct nucleus, and traces of such may be seen in the larger; but the very largest appear perfectly homogeneous and nearly hyaline. In many places, particularly the one furnishing the accompanying illustration, they were so closely crowded as to influence their contours, and the most bizarre shapes resulted, reminding one of other forms of neoplasm (figure 2).

In some instances these bodies seem to have undergone dehiscence, leaving a crumpled, transparent capsule behind. Evidences of this kind are found in the neighborhood of the cavities to be referred to. Clear vesicles, occasionally indenting the contour of the hyaline masses, are also noted here. They resemble those previously described.

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[1] *Zeitschrift für Biologie*, Band ii. page 391.

[2] *Archiv für Psychiatrie*, Band vii. page 447.

In the greater part of the affected area not a single normal nerve fibre can be identified as divided in transverse section. But those fibres running in the plane of the section, such as the *fibræ arcuatæ* and most of the nerve-roots, are not only structurally normal, but react normally to the staining-tests of Weigert. All vestiges of the normal nerve-cells of the facial nucleus (main nucleus) have disappeared, but in the hypoglossal and vagus nuclei the process of death can be distinctly studied. The cells maintain their outline, but within a transparent membrane—if it may be so called—reproducing the cell outline, the protoplasm is found in irregular and separated fragments. This is true of the processes, as well as the body. The nucleus is indistinct. As regards the majority of the normal cell-groups in the affected field, they were either destroyed or crowded out of sight by the abnormal elements. At all events, they cannot be identified.

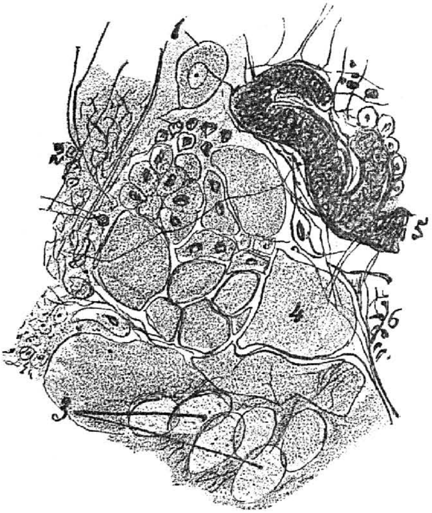

FIG. 2.—1. Element with nucleus, and process. 2. Neuroglia. 3. Vesicular elements in protoplasmic map. 4. Large irregularly contoured elements. 5. Blood vessels.

The few nerve-tubes of sagittal direction remaining intact within the affected area have hypertrophic myelin. Between the zone where such tubes exist and the area of maximum lesion, as well as in the latter, there are a number of clear spaces, resembling those described in the spinal cord as spots of vesicular degeneration by Leyden.[1] These clear spots are a rather accurate gauge of the extent of the lesion in the great fibre systems, since they produce a peculiar spongy appearance, visible under a low power, and even to the myopic naked eye.

The ventricular granulations referred to in describing the recent anatomical appearances, have the usual structure—a fibrillar connective tissue, with included nuclei, occasionally overgrowing and imbedding the endymal epithelium.

On the unaffected—or, rather, the least affected—side of the oblongata there is an exquisite development of spider-cells throughont the entire reticular field, particularly in the triangle bounded by the raphe, vagus roots, and olive. Remarkably enough, no such bodies are found in the area of the neoplasm. These spider-cells are found in greatest abundance in the auditory and upper hypoglossal levels. None occurred in the abducens or decussation altitudes.

In several places the sections of the new formation exhibited gaps. An irregular one is situated immediately caudad of and within the concavity of the right genu facialis. It measured 2 *mm.* in its greatest diameter. A second is situated at the bend of the roots of the vagus, involving in some levels the trineural fasciculus (solitary bundle). A third is found in the reticular field just mesad of the right pneumogastric roots, measuring 3 *mm.* in its greatest diameter. A fourth lies directly in the line of the right abducens roots, interrupting their continuity. A fifth lies at the upper border of the interolivary field, opposite the hilum of the olive; this has been already referred to as being present in the recent specimens. The other four evidently resulted from the sponginess and crumbling of the tissue, and were found situated in the centre of those spots characterized by greatest vascularity. Not the slightest evidence of hemorrhage was found. The contents of many blood-vessels were in a condition of stasis.

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[1] *Klinik der Rückenmarks krankheiten*, Band ii.

TOPOGRAPHY OF THE LESION.

1. Level of the *locus cœruleus*. [Figure 3.]

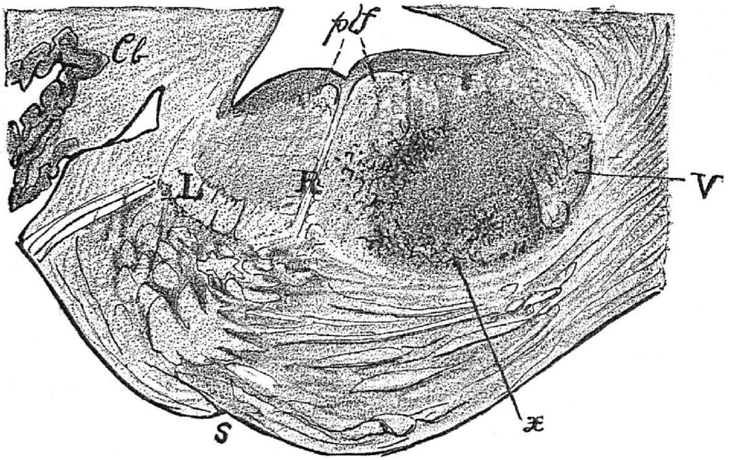

FIG. 3.—Transsection of pons, at lower level of *locus cœruleus plf* posterior longitudinal fasciculi; R, raphe; L, left lemniscus (intact); S, sulcus basilaris; V′, ascending root of trigeminus, on the left side the level is a higher one owing to the asymmetry described in text; X, most vascular part of the new formation.

The diseased area is strictly limited to the right side; it occupies the reticular field of the tegmentum, and the lemniscus; it does not reach the raphe except at the junction of its dorsal third with its ventral two thirds; it does not affect the transverse fibre mass of the pons, the subendymal gray substance, the posterior longitudinal fasciculus, and the locus cœruleus. It slightly invades the right raphe root of the fifth pair. The contour of the focus of disease is therefore round, with a slight flare towards the upper third of the raphe.

2. Level of the abducens nerve-roots.

The diseased area is almost directly on the right side. There is a slight infiltration of the left internal division of the reticular field, not extending as far as the left abducens roots. The raphe is intact. The right posterior longitudinal fasciculus is partially involved by the "vesicular degeneration " adverted to. The general contour of the lesion is the same as in the preceding level. The lemniscus in its middle third, the sagittal fibres of outer part of the reticular field, the lower facial nucleus, and the greater part of the facial root are entirely destroyed. The inner part of the right reticular field, the innermost part of the ascending root of the right fifth pair, and the right abducens nucleus are invaded.

3. Level of the *striæ medullares.*

In this level the encroachment of the lesion beyond the median line is greatest. The internal division of the left reticular field is invaded in its dorsal third; the left as well as the right nuclei fasciculi teretes are unidentifiable. The infiltration, aside from the encroachment on the left side, is bounded by the striæ medullares and the subendymal auditory nucleus above, the restiform body, and its tributary arched fibres laterally, and ventrad it is gradually lost towards the olivary halo. It sends an angular extension to the border of the interolivary layer.

4. Level of the hypoglossal nerves.

The parts destroyed in this level are the dorsal end of the raphe, nearly the entire right and the cephalic part of the left hypoglossal nuclei, the right vagus nucleus in its greater portion, the nucleus ambiguus and the trineural fasciculus (fasciculus solitarius) altogether. The limits of the focus are similar, but more contracted, except in the direction of the interolivary layer.

To complete the topographical survey of the tumor, it may suffice to add, that its cephalic end ceases as a gradual infiltration of the tegmental field at the lemniscus junction. Its caudal end, ceases in the gray matter, which is cut up by the fasciculi coming from the decussation of the interolivary layer. Both cephalad and caudad of the diseased area proper, however, there is considerable asymmetry in the sections.

We are now prepared to inquire into the effects of this abnormal growth on the normal structures of the pons and oblongata. As it involved an enormous hypertrophy of the diseased area, it caused a considerable asymmetry of the brain axis. In the first specimen it had been observed, that while the sulcus of the fourth ventricle nowhere deviated from the straight line, and appeared to occupy the normal axial position, the basilar furrow of the pons deviated considerably to the left. The accompanying figures and the following table illustrate the asymmetry better than any description in words.

If the brain axis be supposed, for the sake of the illustration, to be composed of an expansible mass, and an area corresponding to the right tegmentum and right subventricular region be supposed to have undergone inflation, the distortion in this case becomes clear. In the first place, as soon as the limits of intrinsic expansibility outward are passed, the neighboring parts will participate: the raphe becomes lengthened dorso-ventrad. The consequence is that the comparatively uninvaded left half of the oblongata becomes drawn out in the dorso-ventral direction, and consequently narrowed in the lateral direction. Nowhere is this illustrated more prettily than in the contrast offered to view by the restiform columns of opposite sides. (Fig-

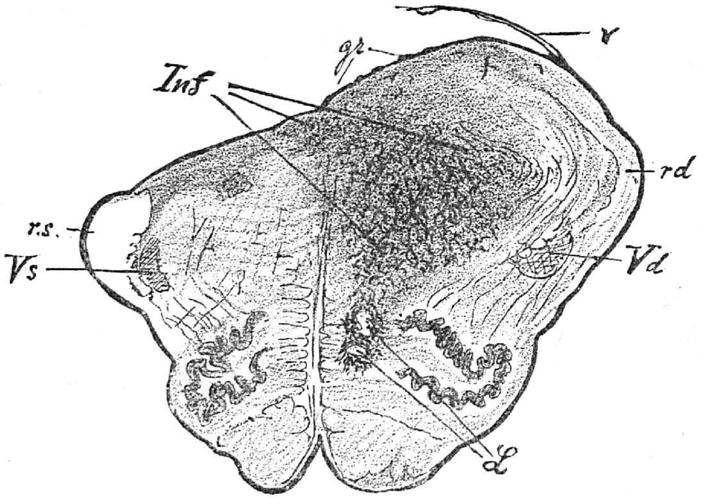

FIG. 4.—Section immediately caudad of the *striac medullares*, *v velum medullare*; *r.s.* left restiform body; *rd* right restiform column, flattened out but normal; *gr* ventricular granulations; *Vs* and *Vd*, left and right ascending trigeminal roots; *L* lacunœ at margin of interolivary larger; *Inf*, new formation infiltrating.

ure 4.) On the left side, it is more compact even than in the normal oblongata; on the right side it is stretched out to a mere film on the outer side of the oblongata. Yet in absolute area the two are equal, the restiform being one of the tracts which has escaped disease entirely. The distorting influence of the neoplastic hypertrophy was not only exerted in the transverse plane. Considerable deformity resulted in the antero-posterior direction. Thus the right half of the pons, on its ventral face, appeared flattened out. In consequence it was wider cephalo-caudad than the more compact left side. Intrinsically the transverse and the longitudinal fibres of the pons were absolutely healthy.

The normal structures directly cephalad and caudad of the neoplasm had been crowded respectively forwards and backwards. Thus in strictly transverse sections in front of the disease focus, the elements on the right side represented what normally should have been a lower level; the corresponding left side representing a higher level. In the same way sections caudad of the growth represented always a higher level on the right than on the left side, inasmuch as the right side had been bulged out caudad. The olive particularly illustrated this; it had been so much compressed, that its cephalo-caudal diameter became shortened to the increase of its transverse area. In texture it, like the equally distorted right pons[1] half, is healthy.

With reference to individual parts of the pons and oblongata, the following recapitulation will show to what extent they are injured or destroyed.

LEFT SIDE. *Internal division of the reticular field:* destructively involved to the ideal continuation line of the hypoglossal nerve-roots, and to the extent of three millimetres dorso-ventrad, in the level of the medullary striæ. In front of and behind this level, a less intense affection, ceasing at the abducens and middle hypoglossal level, is found.

L. nucleus of fasciculus teres: destroyed.

L. hypoglossal nucleus: destroyed in its cephalic and middle thirds.

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[1] Meaning only the pedal part of the pons, that which really represents a bridge under the tegmentum, uniting the cerebellar hemispheres.

L. glossopharyngeal nucleus: destroyed in its internal part, infiltrated in its outer part.

L. vagus nucleus (subendymal): infiltrated near the endymal border.

RIGHT SIDE. *Right posterior longitudinal fasciculus:* slightly involved on its border towards the abducens nucleus, healthy in every other level.

R. tegmentum; internal division: destroyed, with the exception of some fibres next the raphe and interolivary layer, in the transition level. In the abducens level it is nearly intact, being intensely involved, however, in the part pierced by the abducens roots.

R. tegmentum; external division: focus of disease entirely destroyed in trigeminus and facial levels, and with exception of part near olive and lateral field in oblongata.

R. lemniscus. In trigeminus levels the ectal two thirds are destroyed; the internal third[1] intact. The interolivary layer is intact in the abducens level but slightly infiltrated, and the seat of a lacuna at its dorsal-ectal border in the oblongata. (Figure 4.)

R. trineural fasciculus. Destroyed in cephalic half, greatly involved in caudal half.

R. trigeminus nerve. 1. *Raphe root:* slightly invaded. 2. *Motor nucleus:* considerably involved. 3. *Sensory main nucleus:* involvement doubtful; *ascending root:* intact, except at exit level, where about the inner one sixth exhibits a slight infiltration of the septa; the nerve fibres themselves unaffected.

R. facial nerve. 1. *Proper nucleus:* destroyed; *root:* ,‘ fatty ” degeneration at genu and dorsal third of emerging ramus. Singularly enough, the peripheral root shows no other anomaly than a deficient reaction to fuchsine. It stains normally by Weigert's hæmatoxylin method.

R. abducens nerve; nucleus: considerably involved; *roots:* reduced in number, and interrupted in their course by a lacuna. Between the nucleus and the lacuna they are nearly as well developed as those of the healthy side.

R. hypgolossal nerve; nucleus: almost entirely destroyed, except a few cells on the border of the vagus nucleus and the extreme caudal tip of the nucleus in the level of the interolivary decussation, no trace of its normal elements can be found. *Nerve:* Some normally-stained fibres, about one third in number those of the opposite side, preserved.

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[1] “Bundle from pes to tegmentum” of some.

R. glossopharyngeal nucleus: destroyed.

R. vagus nucleus: destroyed in its ventral two thirds; slight infiltration of the remainder. The dark color is due to increased vascularity.

R. vagus nerve: half the normal diameter; normal fibres, except for a defective reaction to fuchsin.

R. deep nucleus of the mixed system:[1] destroyed, and the emerging rootlets cannot be identified.

Both on the left and right side, the anterior pyramids, the sagittal and transverse fibres of the pons proper, the olivary nuclei, those arciform fibres which pass through the olives, the restiform columns, the "internal division[2] of the cerebellar peduncle," and the auditory nerve-roots are entirely free from disease. The right subendymal auditory nucleus show a richer vascularization than the left, but there are no destructive changes. The right *nucleus magnocellularis* of Deiters, exhibits considerable infiltration in the molecular net-work, but the cells and fibres themselves appear as normal as those of the left side. The striæ medullares are normal up to within a millimetre of the median line, where (in the fresh specimen) they became lost in the gelatinous transformed mass. Microscopically, the fibres were found normal up to this point.

A singular feature is the healthful appearance of the peripheral nerves, considering the atrophy of some of their roots. The right facial is nearly entirely degenerated at the *genu;* the right abducens cut across by a lacuna, and the right hypoglossal represented by fewer radicles than the left. Aside from a diminution in size and number of the nerve-tubes in the right facial, abducens, and hypoglossal nerves, nothing abnormal could be found in them. Probably the total destruction of the nuclei and the interrupting lesions had occurred too recently before death. In the intra-cerebral course of the facial, degenerative changes were advancing towards the periphery. As to the glossopharyngeal and vagus rootlets a number of them were lost in preparation, and nothing positively abnormal found.

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[1] The probable axial nucleus of the pharyngeal and laryngeal nerves, "Architecture and Mechanism of the Brain," JOURNAL OF NERVOUS AND MENTAL DISEASE, 1870.

[2] Regarded by some modern investigators as an auditory root.

In attempting to establish a relation between the symptoms and the lesion in this case, we must assume a progressive involvement of various centres and tracts, beginning at that point which lies in the centre of the morbid growth, and which corresponds to the functional disturbance. It happens that both indications point to a spot corresponding to the reticular formation of the tegmentum, near the nuclei at the floor of the fourth ventricle and in the plane of the abducens and pneumogastric nerves.

In the following table I have attempted to indicate the chronological and topographical relations of the main symptoms.

Date.	Symptom.	Explanation.
	Motion of the Extremities.	
1884, Feb.	Dragging of the left leg.	The temporary paresis (?) cannot be accounted for ; the ataxia of movement resulted from disturbed muscular sense ; see the latter.
1884, May.	Normal again in all respects.	
1884, July.	Ataxia of movement on left side.	
	Cutaneous Sensation of the Extremities.	
1883, Oct.	Subjective left heminumbness.	The lesion began in the reticular field of the tegmentum, probably intermediate to the raphe and ascending trigeminus root. Owing to the total destruction of this tract, the question arises, Are there other cutaneous sensory tracts, sensation not being entirely destroyed, but merely perverted ?
1884, Jan.	" " sensation of pins and needles.	
	Subjective left paræsthesia (cold feeling).	
1884, May.	Pressure sense of left side impaired.	
	Muscular Sense of Extremities.	
1884, May.	Doubtful impairment on left side.	The interolivary layer of the right side was involved late, the lemniscus earlier.
1884, July.	Decided impairment on left side.	
	Cranial Nerves—Pupils.	
1884, May.	Indolent reaction to light, tendency of pupils to remain in contraction after accommodation and exposure to light. This symptom thenceforth stationary.	In most focal pons affections reflex iridoplegia has been observed; the lesion in them extended further cephalad and further dorsad in cephalic levels.
	Conjugate Eyeball Movements.	
1884, March.	Dancing motion of objects.	This case corresponds to those described by others: involvement of the reticular field near the posterior longitudinal fasciculus.
1884, May.	Associated movement to the right beyond the median plane, entirely destroyed and nystagmus. Former stationary, latter decreases.	

Date,	Symptom.	Explanation.
	Right Abducens Nerve.	
1883, Sept.	Blurred vision, temporary.	Early, slight involvement; later, destructive lesion in root transit and more serious involvement of nucleus,
1883, Nov.	Temporary diplopia.	
1884, May.	Paresis.	
1884, July.	Nearly total paralysis.	
	Fifth Pair, Sensory Branch.	
1884, May.	Subjective numbness of R side of face.	Slight involvement of sensory ascending and raphe root, later, of sensory nucleus of exit level.
1884, July.	Subjective sense of heat on R side of face.	
	Fifth Pair, Motor Branch.	
1884, March.	Tightness of jaws.	At first, irritative lesion of; later, slight infiltration of motor trigeminus nucleus.
1884, April.	Continued difficulty of mastication.	
1884, May.	Paretic weakness of R masseter.	
	Right Facial Nerve.	
1883, Oct.	Spasms of.	At first, irritative lesion; later, total destruction of.
1884, May.	Total paralysis of all external branches, the uvula deviating to the right.*	
	Right Auditory Nerve.	
1884, April.	Buzzing in right ear without assignable cause.	Possibly hyperæmia of nucleus, which was found injected.
	Taste.	
1884, May.	Slightly impaired (delayed appreciation) on right side.	R solitary bundle and R glossopharyngeal nucleus destroyed. L glossopharyngeal nucleus involved later on.
1884, July.	Profound bilateral impairment, not accurately mapped out.	
	Deglutition.	
1883, Sept.	Spasmodic disturbances of.	Subendymal and insular nuclei of vagus and accessory nerves first irritated, then destroyed, or nearly so.
1884, Jan.	Pharyngeal paresis (nasal, voice, etc.) general.	
1884, March.	Eructation difficult.	
1884, July.	Deglutition progressively becomes paralyzed.	
	Larynx.	
1884, May.	Normal.	The insular nucleus of the "mixed system" was destroyed.
1884, July.	Undetermined.	
	Gastric.	
1883, June.	Nausea, vomiting, and irritability of the stomach, which can be obviated to some extent, as in sea-sickness, by remaining motionless, continues nearly till death.	Subendymal nucleus of vagus nearly destroyed after preceding irritative infiltration.
1884, June.	Bulimia.	
1884, July.	Anorexia.	
	Renal.	
1884, May.	Urine normal (Dr. Powell).	The affection of both vagus nuclei must account for the polyuria.
1884, July.	Polyuria (?).	
	Cardiac.	
1884, March.	Intermission of the heart-beat at long intervals, increasing in frequency.	Ditto

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* It is recorded in several cases of total facial palsy that the uvula deviated in the direction contrary to the one regarded as the rule.

Date.	Symptom.	Explanation.
1884, July.	Heart's action intermittent and irregular.	
	HYPOGLOSSAL NERVE.	
1884, May.	Tongue, as a whole, deviates to the right with inclination of the tip to the left.	The hypoglossal nuclei were both involved early, in their upper portion, and nearly destroyed, *sub finem*, together with their raphe connection.
1884, July.	Deviates to the left as a whole, is the seat of fibrillary tremors, is asymmetrical, the right side being the larger; protrusion is difficult; *sub finem*, complete anarthria supervenes.	
	CERVICAL MUSCLES.	
1884, July.	Oscillatory motion of head, with passive rotation of head to left.	?

As I am engaged in preparing a monograph on the lesions of the oblongata, I limit myself for the present to giving a history of this case and its findings, trusting to discuss its points of agreement and contrast with the cases of others, at no remote date, in the paper referred to.

712 Lexington avenue, July, 1886.